The Fuller Calculating Instrument

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Introduction

We consider the Fuller slide rule to be one of the most attractive of all of the many varieties of slide rules that were ever made. In this paper we have begun to piece together the facts concerning the, history, manufacture, distribution and types of Fuller Calculators. A list of surviving rules, known to the authors, has been prepared. In addition, a plot of the serial numbers versus the date of manufacture has been prepared and estimates of the total number of rules and the rate of rule manufacture has been made.

Fuller and His Slide Rule

George Fuller, Professor of Engineering at Queen's College Belfast, invented a slide rule that would be used for more than 90 years. On May 7, 1878 he was awarded British patent 1044. The slide rule consisted of a logarithmic scale of numbers spiral wound in the form of a helix. The scale is 500 inches (41.67 feet) in length having 7250 divisions. By comparison, this rule was reported [1] to be equivalent to a straight slide rule that was 83 feet 4 inches long or to a circular slide rule 13 feet 3 inches in diameter! The Fuller slide rule could be held in one hand while performing calculations. It came with a wooden case to which a brass rule holder could be attached and which held the rule when it was not being used, as is shown in Figure 10.1.

It is not known whether George Fuller was in any way related to John E. Fuller [2], the inventor of Fuller's Time Telegraph, which appeared on the market around 1847.
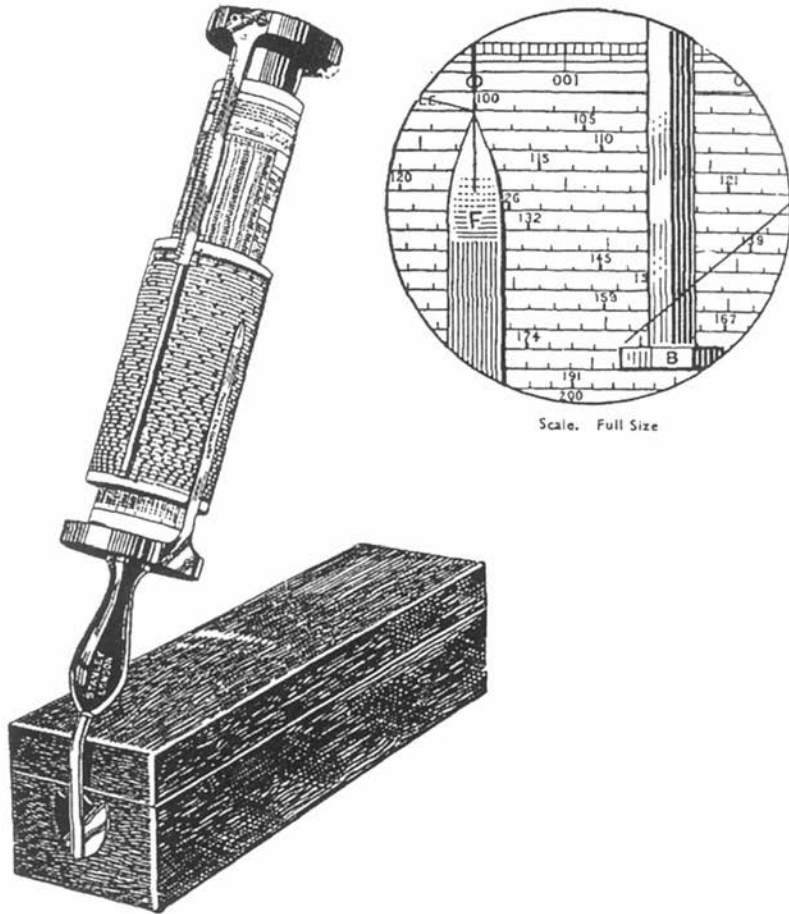
Description of the Fuller Slide Rule

The Fuller Slide Rule consists of a hollow cylinder which can be moved up and down or around an inner cylinder to which is attached a handle. A single logarithmic scale is wound around the outer cylinder. There are two indexes; a fixed index attached to the handle, and a movable index attached to a brass tube which slides up and down in the inner cylinder. The movable index has two reference points separated by one complete length of the spiral scale and an engraved scale of equal parts for finding logarithms of numbers. The inner cylinder has tables of data and useful information affixed to its surface.

Ratios are established by setting a number to the fixed index and a second number to the movable index, then bringing any other number to the fixed index and reading the fourth term in the proportion at the movable index.

Mantissas of logarithms can also be determined by setting the upper reference point of the movable index to a number and taking the sum of the reading on the scale on the movable index and the scale encircling the top of the sliding

THE FULLER CALCULATOR

Scale. Full Size

The simplest and quickest Calculator, giving an accuracy of at least 1-10,000.
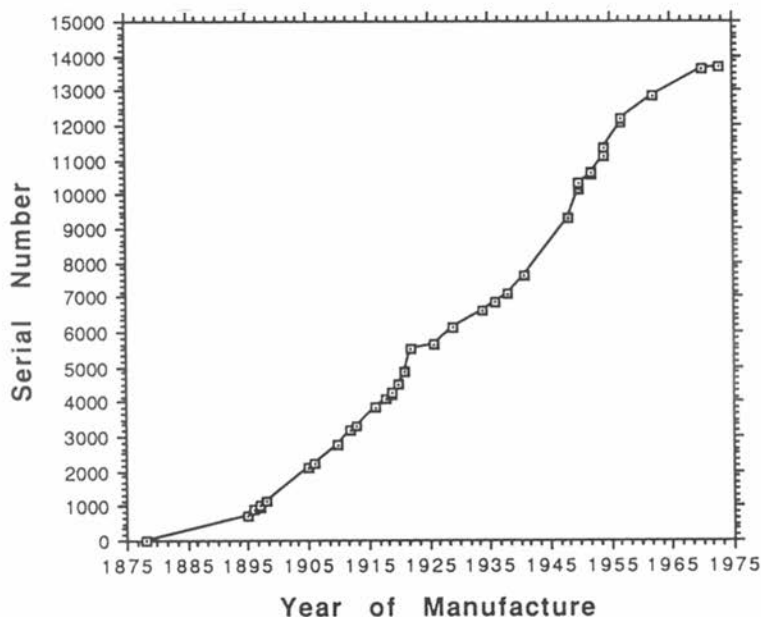
Figure 10.1: The Fuller Slide Rule.

Figure 10.2: Fuller Slide Rule Production.

cylinder. The characteristic of the logarithm is then determined by inspection and added to the mantissa to complete the logarithm. Having the logarithm of a number, it becomes an easy matter to raise it to any exponential power or use it to determine any root, by simple arithmetic, and then reversing the process to find the antilogarithm.

Production and Timing

Production of the Fuller Slide Rule began in 1879, the date shown on the first instruction book. All of the rules were manufactured by the W.F. Stanley Company of London, England. Their 1960 General Catalog shows three types were available at that time [3].

On the brass movable index are stamped two numbers, the serial number, and for rules made after about 1900, the last two digits of the date. All of the serial numbers were applied by Stanley at time of manufacture and are believed to be consecutive ranging from presumably 1, to about 14,000.

We know of one Fuller Slide Rule dated as late as 1973 which gives an overall production span of at least 94 years.

A plot of serial numbers versus year of manufacture is shown in Figure 10.2. If a straight line of best fit is drawn through these points its slope gives an average production rate of about 180 rules per year or 15 per month.

One should keep in mind that of the approximately 14,000 Fuller Slide Rules made, we know of only 45, or 0.32%. It is difficult to make broad generalizations

on the basis of such a small sample and it is likely that there will be interesting surprise findings in the future.

Other Suppliers of Fuller Slide Rules

Of the four types of Fuller Slide Rules known only, the Type 1 appears to have been sold by suppliers in the United States who obtained the rules from Stanley and simply added their own labels. K&E Catalogs from 1895 through 1925 [4], and the 1891–1892 edition of *The Compass* [12], show it first as Model 1742 and after 1900 as Model 4015 .

The Thacher and Fuller Slide Rules are shown on opposite pages in the 1915 Keuffel and Esser Catalog. It is interesting to note that K&E is careful to point out that the Fuller Slide Rule requires setting each time the third term of a proportion changes, and it does not give a complete series of equal ratios at sight, like the Thacher, Mannheim and Duplex rules which they manufactured themselves. They also mention that in prolonged use the weight of the rule is a disadvantage, as it must be held by hand! A Dietzgen Catalog from the same era is much more upbeat about the Fuller Slide Rule and Dietzgen points out that the rule can be operated while attached to its box stand.

Dietzgen catalogs [5] from at least 1904 through 1938 show only the Type 1 Fuller Slide Rule as Model 1794. It also appears in the 1921 Acme Blue Print Paper Catalog [6] as Model 2094 and the 1925 Elliott Brothers Catalog #3 [7] as Model 2394 with a storage box and instructions. It is not listed in the 1941 Elliott Brothers Catalog #6. Between 1925 and 1938 it seems that the demand for the Fuller Slide Rule in the United States had greatly declined and it was dropped from all domestic catalogs, although in England it enjoyed an extended life. Dr. Graham Swift reports that Fuller Slide Rules were in use at the University of London in the mid 1960's. The Fuller Slide Rule preceded the Thacher Slide Rule by 10 years [8] and out-lasted it by as much as 25 years giving, it a record for slide rule longevity.

The construction of Fuller Slide Rules is generally typical of late 19th and early 20th Century English slide rules. Many types were fabricated by gluing printed paper scales to the frame of the rule. They were simple, accurate, and economical to manufacture compared to scales engraved upon hard materials. The rules were then varnished to seal and protect the scales from water and dirt. The contemporary Thacher Slide Rule, which was also originally made by the W.F. Stanley Company, at about the same time as the Fuller Slide Rule, was constructed in a similar way by the lamination of printed paper scales to the sliding cylinder and scale supports. The frames and handles of Fuller Slide Rules made before about 1948 were of mahogany wood, but after that time, a molded Bakelite composition was used in place of the wood. The earliest Bakelite Fuller Slide Rule known is dated 1948.

Types of Fuller Slide Rules

There are four basic types of Fuller Slide Rules. Today's nomenclature is the

same as that used in the 1960 W.F. Stanley Catalog with the exception that there is an early variation of Type 2, giving rise to subcategories 2A and 2B.

It has been noted in examining Stanley instruction books that a number of minor changes have occurred in the design features of the Fuller Slide Rule. Most notable are changes in the shapes of the indexes. There is insufficient information available at this time to speculate as to whether further subdivisions of the major types are warranted.

Type 1

In W.F. Stanley's Instruction Book [1], dated 1879, there are directions for using the Type 1 or what might be called the "standard Fuller Slide Rule." In addition to the 500 inch spiral scale, it had a scale engraved on the movable index and one around the top of the sliding cylinder which together can be used to find the logarithm of a number. Tables of useful data are also affixed to the central tube for ready reference.

Type 1 rules have been noted with and without the brass holder which fits into the handle. Those without the holder also have handles that are not drilled to accept the holder. Some rules of this type have the word "Calculator" painted across the top of the storage box in large black letters.

The Type 1 rule seems to be the most common type of Fuller Slide Rule.

Type 2 Rules: The Trigonometric Fuller Slide Rule

The Type 2A Rule

The Type 2A rule appears in the 1907 Stanley Instruction Book [9]. It has a sine scale with values from $5°45'$ to $88°$, in place of the data tables on the central tube, which can be used for trigonometric calculations as well as navigational applications. The sliding cylinder has a notch on one end with a small brass pointer for locating numbers on the sine scale.

It is interesting to note that the only Type 2A rule known, has a wooden handle that is threaded and removable from the rule. It fits into much smaller box than the standard Fuller Slide Rule ($14.0 \times 4.25 \times 4.0$ vs. $17.75 \times 4.31 \times 4.0$ inches). The box also differ from the other larger boxes in that it has a leather carrying handle which folds nearly flat on top of the box when not in use. Like the Type 1 rule, the Type 2A rule has a logarithm scale engraved on the movable index and printed on the upper edge of the cylinder.

The Type 2B Rule

In the 1940 Stanley Instruction Book [10], a Type 2B rule is shown, which in addition to the sine scale, also has a four place logarithm scale on the central tube. There are brass pointers attached to either end of the cylinder to locate values. There is no engraved logarithm scale on the movable index or the printed scale on the top of the cylinder.

This rule is far less common than the Type 1, and is usually referred to as a "Type 2 Fuller Slide Rule."

Type 3: The Fuller–Bakewell Slide Rule

The 1879 Stanley Instruction Book contains a description of a second instrument, the Fuller-Bakewell Slide Rule. Here, the central tube has two logarithmic scales useful for surveying calculations. One scale gives the square of the cosine of angles and the other, the product of the sine and cosine of angles. With these scales, horizontal distances and elevations can be calculated from stadia measurements and telescope angles with the horizontal plane. There are brass pointers attached to the sliding cylinder for locating values on the scales of the central tube.

The authors do not know of any Fuller-Bakewell Slide Rule and thus they seem to be quite rare although they were offered from 1879 through at least 1960.

Type 4: The Mysterious "Midget" Fuller Slide Rule

The 1879 Stanley Instruction Book also has a brief description of a Type 4 rule which is a smaller version of the Type 1 rule with a 200 inch scale and an accuracy reported to approach 1/4000 [1].

In the author's copy of the instruction book, which is believed to be the first edition, the description of this smaller rule has been very carefully lined out with a pencil and ruler. Thus, there is a question as to whether this model was ever actually produced. The 1907 and 1940 Stanley Fuller Instruction Books, as well as the 1888 edition of the Stanley General Catalog [11], make no mention of this rule. Again we know of no Type 4 rules in existence today or if there ever were any.

Accuracy of Various Slide Rules

The linear distance between 1 and 2 on a logarithmic scale is 6.57 times larger than the distance between 9 and 10. Hence numbers read near the left hand index will inherently always be read with greater accuracy than those near the right hand index.

In an article reported in *The Compass* [13] on the accuracy of various calculating devices available in 1891, it was found that with very carefully performed operations that the Fuller Slide Rule gave a mean error of 0.008% or ± 1/12,500. By comparison the Thacher Slide Rule gave a mean error of 0.0031% or ± 1/32,000.

Note of Interest

Nevil Shute Norway, an early aeronautical engineer in the late 1920's, made the Fuller Slide Rule known to a wide audience in his autobiography *Slide Rule*, which he wrote under the pen name Nevil Shute. As a young engineer, he was Chief Calculator, determining forces and bending moments during the design and construction of the famous British dirigible, the R-100. He specifically mentions using a Fuller Slide Rule to make these calculations in his book [14].

Fuller Slide Rules Still in Existence

	YEAR	SN	TYPE	NOTES	SOURCE
1	1885	741	1	NO DATE	FEELY
2	1890	884		NO DATE OR HOLE	KENNADY
3	1897	979	1	NO HOLE	
4	1897	1030	1	NO HOLE	
5	1897	1045		MAHOGANY	HARDING
6	1897	1050	1	MAHOGANY	MORRIS
7	1898	1115	1	CASE / INSTR. MAN.	GEMMARY
8	1905	2104	1	BODY ONLY	MEEKER
9	1906	2215	1	1904 INSTR. BK.	BAILEY
10	1910	2782	2 A	MAHOGANY	FEELY
11	1912	3198		MAHOGANY	
12	1913	3320	1	MAHOGANY	FEELY
13	1916	3849	1	K&E 4015	FEASEL
14	1918	4034	1	CASE / INSTR. MAN	GEMMARY
15	1918	4074	1	MAHOGANY	FEELY
16	1919	4173	1	MAHOGANY	SCHURE
17	1919	4282	1	MAHOGANY	
18	1921	4502	1	MAHOGANY	SCHURE
19	1921	4879		MAHOGANY	
20	1922	5515		MAHOGANY	
21	1926	5625	1	MAHOGANY	OTNES
22	1929	6119		MAHOGANY	
23	1934	6581		MAHOGANY	
24	1936	6848	1	MAHOGANY	OTNES
25	1938	7090	2B	MAHOGANY	SCHURE
26	1941	7638	2B	MAHOGANY	BOLOTSKY
27	1941	7639		MAHOGANY	
28	1942	7822	1	MAHOGANY	GEMMARY
29	1948	9325	2B	BAKELITE	GEMMARY
30	1950	10127	1	BAKELITE	
31	1950	10232	2B	BAKELITE	BAILEY
32	1950	10305	?	BAKELITE	BARNES
33	1952	10579	2B	BAKELITE	GEMMARY
34	1952	10619	2B	BAKELITE	
35	1954	11086	2B	BAKELITE	
36	1954	11368	1	BAKELITE	
37	1954	11369	1	BAKELITE	GEMMARY
38	1956	11701	1	BAKELITE	WEAVERS
39	1957	12079	2B	BAKELITE	
40	1957	12186	1	BAKELITE	BAILEY
41	1962	12815	1	BAKELITE	FEELY
42	1970	13606		BAKELITE	HUDSON
43	1970	13646	2B	BAKELITE	SHEPHERD
44	1973	13670	2B	BAKELITE	BABCOCK
45	1973	13688	1	BAKELITE	SCHURE

Figure 10.3: Known Fuller Slide Rules.

Known Fuller Slide Rules are listed by serial number and type in Table 10.3. The Table contains all of the data known to the authors at the time of publication.

The authors would appreciate any additional information that our readers might supply about their Fuller Slide Rules, or those that they have seen in their travels. Specifically, we would like to know the serial number, type and any other details as to instruction manual, construction, case, etc. We also have very little bibliographical data on George Fuller and it would be helpful if any of our readers could supply additional information.

References

1. W.F. Stanley Co., London, Fuller Calculator Instr. Manual, 1879.

2. Bobby Feazel, "Palmer's Computing Scale," *Jour. Oughtred Soc.*, Vol. 3., No. 1, 1994.

3. W.F. Stanley Co., London, *Catalog*, 1960.

4. Keuffel & Esser Co., NY, *Catalogs*, 1895–1925.

5. Eugene Dietzgen Co., Chicago, *Catalogs*, 1904–1938.

6. Acme Blue Print Co., Chicago, *Catalog*, 1921.

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9. W.F. Stanley Co., London, *Fuller Calculator Instruction Manual*, 1907.

10. W.F. Stanley Co., London, *Fuller Calculator Instruction Manual*, 1940.

11. W.F. Stanley Co., London, *Catalog*, 1888.

12. Keuffel & Esser Co., NY, *The Compass*, W. Cox, Ed., Vol. 1, 1891–1892, page 66.

13. Keuffel & Esser Co., NY, *The Compass*, W. Cox, Ed., Vol. 1, 1891–1892, page 124.

14. Nevil Shute, *Slide Rule*, , William Heinemann Ltd., Melbourne, 1954, Chapter 3 (exact page varies with edition).